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An Introduction to Web3 with Implications for Financial Services

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Summary:

Web3 is used to describe the next iteration of the internet in which decentralized services are automated on blockchains. This paper describes the elements of Web3 including blockchains and tokens. It describes the largest decentralized finance protocols and some specific services where blockchain and tokens can be used. The paper concludes with a brief discussion of some regulatory challenges.

Key findings:

1. Web3 seeks to replace an internet based on centralized intermediaries with one that is not. The term Web3 refers to the use of blockchains and cryptocurrencies or tokens.
2. Tokens are a piece of code that signify ownership or control of an asset. Many different token designs are possible.
3. Decentralized finance has developed novel ways to trade assets, make collateralized loans, and make payments.
4. Blockchains and tokenization could be used to improve efficiency and provide new services in currency exchange, trade finance, remittances, making assets such as real estate more liquid, and improving domestic payments.
5. A regulatory challenge is updating regulation to accommodate the changes in infrastructure.

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1 Introduction to Web3

The term Web3 is used to describe the next iteration of the world wide web or internet. It is anticipated to be the successor to Web 2.0, which is currently organized around centralized intermediaries such as Amazon, Google, and Microsoft. Such entities store data, verify identity, and provide or intermediate services. The widespread adoption of this centralized model of the internet has led to the rise of online shopping, online banking, streaming services, and social networking. The goal of Web3 is to organize similar services that are not intermediated by large companies. Thus, the definition is more aspirational than precise.

As a matter of common usage, Web3 is used to refer to the use of some combination of blockchains and cryptocurrencies (tokens) to provide decentralized products and services. Web3 projects usually share four features: they are open source, they have their own cryptocurrencies, anyone can use them, and users interact with them through a blockchain.

For open-source Web3 projects, code is publicly posted and verifiable. The idea motivating this transparency is decentralization: if anyone can check the underlying code, there is no need to blindly trust the entrepreneurial group. A consequence of such process transparency is that successful projects are often replicated, albeit with slightly different branding.[1] The benefit of open-source code is that it accelerates the pace of innovation (others can build on it efficiently), a cost is that it can be exploited if there are vulnerabilities.

Rapid innovation in Web3 and the subsequent proliferation of projects has led to more than 23,000 distinct cryptocurrencies.[2] This growth in cryptocurrencies is because, in order to build services that are not delivered by large intermediaries and are not based on the users' identities, Web3 protocols need to have a decentralized, anonymous way to transfer value and information, which is typically is done through cryptocurrencies or tokens. These are usually designed in conjunction with the project's code to strengthen users' economic incentives to interact with the project.[3]

Services offered are not conditioned on individual identity. For this reason, interactions on blockchains are described as being pseudonymous, because interactions are initiated from specific addresses (which are observable), but the individual or business behind the addresses is not necessarily known. Further, any individual can control multiple wallets and generate new ones at will. In the absence of identity, collateral in the form of cryptocurrency frequently

[1] The successful decentralized exchange Uniswap V2 was replicated by Sushiswap and Pancakeswap, among others. When Uniswap launched its V3, the firm obtained a business source license (BSL) so that even though the code was open source it could not be used to launch an identical exchange until the license expired.

[2] As of May 1, 2023, Coinmarketcap reports 23,719 cryptocurrencies with a combined market capitalization of 1.2 trillion USD.

[3] Models which characterize the relationship between platforms and cryptocurrencies include Cong, Li and Wang (2021) and Cong, Li and Wang (2022).

substitutes for trust or reputation. Thus, in Web3 instead of interactions based on identity, interactions occur through the use and exchange of digital assets or tokens. The use of tokens means that services can be accessed by anyone who has a token and in this way is egalitarian.

There are two ways in which Web3 and tokenization may affect finance. First, it might reduce costs, and second, it could lead to innovation in how we provide standard financial services. Reducing operational costs will increase welfare, while using different business models to provide standard financial services might affect both the industry and effectiveness of regulation. To understand these possibilities, first consider the building blocks of Web3—blockchains and tokenization.

Blockchains

An array of different blockchains power Web3. While the Bitcoin blockchain (and its eponymous cryptocurrency) has the largest market capitalization and is the most well known, there are many other blockchains.[4] Currently, there are well over 200 blockchains in operation. Figure 1 lists the top five public blockchains ranked by the number of active protocols or applications running on them. Also noted is the Total Value Locked (TVL), which is a crude measure of use that captures the current market value of cryptocurrencies that are deployed on a chain.

Chain	Protocols	Total Value Locked (bn USD)
Ethereum	753	28.75
Binance Smart Chain	586	4.63
Polygon	408	1.04
Arbitrum	306	2.15
Avalanche	302	0.79

Figure 1: Top five blockchains ranked by number of protocols or applications. Total value locked is the current dollar value of cryptocurrency locked as collateral in the various applications. Data are current as of April 23, 2023.
Source: DefiLlama.com

Once launched, each blockchain is designed to be economically self-sufficient and so to operate in perpetuity (although some fail). For each of these chains, blocks of data are compiled and appended to earlier ones by operators usually referred to as validators or miners. These economic agents perform tasks in return for remuneration denominated in the blockchain's native cryptocurrency. Transfers are made either automatically by the governing software or by users of the blockchain ecosystem.

The chain most pertinent for financial innovation is the Ethereum blockchain. Ethereum

[4] Apart from a few payment applications such as the lightning network, there has been limited infrastructure development on the Bitcoin blockchain.

is designed to be a publicly accessible and universally observable computer.[5] The Ethereum blockchain stores data from transactions and programs that have been added to the system. Roughly, data are sorted and stored in specific locations called "wallets" or "addresses." Users of Ethereum can send value from one address to another, store computer programs at an address, and execute or interact with those programs.[6] These programs are often referred to as "smart contracts" and are effectively vending machines in that the same input to an address will always generate the same output. For this reason, the Ethereum blockchain is sometimes referred to as "the Ethereum virtual machine" or EVM.

It should be noted that, evaluated as a computer, the EVM is slow and cumbersome, although all the basic computations we expect computers to do can be performed on it.[7] The benefit or innovation of the EVM is that it is publicly accessible, decentralized, and observable. As each blockchain is, quite literally, a chain of blocks, all past actions can be observed, albeit imperfectly.

Because anyone with a computer can observe transactions on the EVM and join the ecosystem, Ethereum is described as a public blockchain. By contrast, there is a small but growing set of blockchains that are described as permissioned or private. Examples of private blockchains include Corda from R3, Hyperledger Fabric, Provenance, and Ripple, among others. Such blockchains restrict access to participants who have been verified offchain and typically focus on institutional use. These blockchains are also not decentralized in that the consensus mechanism is more akin to "agreement" than "independent verification." However, they do retain most of the other features of public blockchain and act as virtual machines. The waves of innovation in decentralized finance/Web3 have come from the public blockchains, because the barriers to entry are low and code, as noted, is open source.

Decentralized Applications or Protocols

Decentralized applications (or dapps) operate as automated businesses that can perform a variety of activities from trading to making collateralized loans or facilitating gaming. Each of the basic actions that the dapps performs is governed by a smart contract or computer code. This code can either be written for the dapp or part of another protocol. In much the same as way as traditional businesses can outsource back-office operations, a dapp can interact with any smart contract or code that has already been posted on the blockchain where the dapp resides.[8]

Frequently, dapps are initiated by a programming group and then operate independently (without active management). These are referred to as decentralized autonomous organizations,

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[5] The Ethereum blockchain was proposed in 2013 and went live in 2015. The native token is ETH.

[6] Programs are stored by sending computer code to a known wallet address, and the return value is an address where the program resides. Other users can then interact with this address.

[7] The EVM is Turing complete.

[8] This property means that smart contracts are "composable."

or DAOs. Changes are authorized by votes of governance token holders. These novel governance structures present complications for regulators, who have historically engaged with an obvious legal entity. In light of these unique features, the state of Wyoming defined a special legal structure that accommodates DAOs.[9]

Tokenization

Dollar bills and bearer bonds are both tokens. Further, the act of transferring a dollar bill or bearer bonds transfers the value inherent in them, which is the benefit of tokenization: it enables delivery against payment or more broadly makes it clear who has the right to use or dispose of the asset. We are used to tokens representing value such as fiat currency. However, anything can be tokenized, such as copyright, access, or voting rights; even past service or the rights to a further service can be tokenized. Finally, a token may represent unique items or collectibles.

For the purposes of this discussion, the term token and cryptocurrency can be used interchangeably. In Web3, a token is not physical, but is a piece of code. Ownership of the code is synonymous with being able to deploy it, which typically means moving it to a different wallet address.

It is important to note that, because they are code, there are many different cryptocurrency designs. The most common type in circulation adhere to the ERC20 standard. (This refers to Ethereum Request for Comments No. 20.) The source code is open source and freely available.[10] All ERC20 tokens are completely fungible—that is, no token is unique. Nonfungible tokens often follow the ERC721 standard. Under this token design, the metadata automatically retain transactions history and thus can be used to verify provenance or authenticity especially if linked to a physical object.

Clearly, the design of tokens offers flexibility, which is a potential benefit for financial use cases. Financial authorities and innovators have been exploring this flexibility. Project Guardian is spearheaded by the Monetary Authority of Singapore to experiment with and develop standards for tokenized assets.[11] The authority has experimented with cross-border value transfer and digitized deposits. Another example is an open-source standard, ERC-3643 (formerly T-Rex), which is effectively a permissioned token. This token restricts transfers to only accredited investors that satisfy know your client (KYC) and anti–money laundering (AML) checks. In this way, tokenized assets that are regulatory compliant can circulate on a public blockchain.[12]

It is important to recognize that tokenization may or may not occur on a blockchain. As

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[9] https://www.wyoleg.gov/Legislation/2021/SF0038

[10] The documentation appears athttps://eips.ethereum.org/EIPS/eip-20.

[11] See https://www.mas.gov.sg/schemes-and-initiatives/project-guardian.

[12] Tokens can also be used to represent different characteristics of the underlying asset. These distinctions rest at the intersection of law and technology.

noted above, dollar bills are tokens that are physical and not virtual. Further, digitized deposits in a bank are like tokenized dollars that can circulate only within that bank. But using tokens on a blockchain confers various benefits. First, blockchains are transparent: users can verify that value transfers have occurred. Second, as the sequence of transactions is stored, blockchains are easy to audit. Finally, as noted above, blockchains may have computing capability. As a result, value can be automatically transferred only if various conditions are met, such as periodic loan repayments or property title transfers.

2 Decentralized Finance

Decentralized finance is made up of automated protocols (dapps) that allow individuals (or algorithms) to perform various activities such as transferring, trading, swapping, lending, and earning tokens. Obviously, many technical details go into these protocols, and these details are the provenance of computer scientists. Economically, these protocols automate many activities that we are used to observing in financial markets (albeit in a novel way). To clarify this notion, consider three core financial services: exchanging value, collateralized lending, and making payments.

Exchanging Value

Value is swapped in decentralized markets primarily through automated market makers. Notable examples include Uniswap and Curve. Briefly, these protocols separate liquidity provision from price discovery. In most posted price mechanisms (such as limit order books), a party willing to trade indicates the price at which it would be willing to transfer value. In automated market makers, traders decide if they want to supply or demand liquidity. Then, conditional on a trade, prices are explicitly calculated as a function of the amount of the volume of liquidity supplied.

Consider a stylized automated market maker that facilitates trade between token a and token b. (There is no natural numéraire asset, so value transfer is typically in the form of swaps.) A liquidity supplier deposits an equal amount of both tokens. The liquidity supplier receives another token (a liquidity token) that is their receipt for the deposited amount that can be cashed in for the equal amounts of the two tokens in the future. In this way, supplied liquidity accumulates in a swap pool. Suppose that A and B are the respective quantities of the two tokens.

Someone who wants to buy x of token a trades against the resting liquidity in the pool. The terms of trade are calculated mechanically from the resting liquidity and the size of the order, x. If someone wants to buy token a, they will reduce the standing liquidity by x to $A - x$. The protocol automatically calculates the quantity of b tokens that the trader has to deposit (their cost). Specifically, the cost in b tokens to buy x tokens of a satisfies

$$\begin{aligned} (A - x)(B + \text{cost}) &= A\,B \\ \text{cost} &= \frac{A\,B}{A - x} - B. \end{aligned}$$

This formulation has the property that the larger the amount traded (in this case x), the larger the price impact. Thus, these markets generate a similar tradeoff between trade size and

price impact as do standard limit order books. The market participants, through their choice to submit liquidity, affect the size of A and B and therefore the price impact of the pair. This trade is illustrated below.

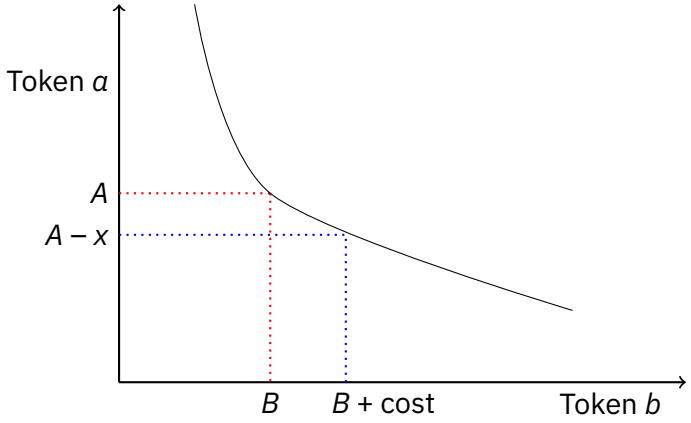

Figure 2: From an initial amount of A and B, respectively, a trader who buys x removes that amount and leaves a balance of $A - x$ tokens. In exchange, they deposit the cost of the transaction, leaving B + *cost* of the other token.

The specific formulation is that of a constant product market maker. It is used on Uniswap V2.[13] Other automated market makers (AMMs) have different functions that relate liquidity to price impact. Most notably, Curve has a price function that allows tokens to trade 1:1 for most quantities, because Curve is designed for stablecoins that are fiat pegged and therefore should trade with limited price impact. As with most aspects of decentralized finance, the design of these automated market makers is an area of active experimentation.

Academic studies have examined various aspects of AMMs, which provide deep markets for the swap pools that we observe. Lehar and Parlour (2021) document the properties of Uniswap V2 and show that prices are aligned with those in centralized exchanges.[14]

Collateralized Lending

Collateralized lending is also conducted in a novel way in decentralized finance. The large lending protocols, Compound and AAVE, are platforms that intermediate borrowers and lenders. Roughly, the systems are designed to mitigate credit risk and ensure that loans are liquid.

Consider a stylized version of the Compound protocol. For simplicity, suppose that token ℓ is being lent while token b is being borrowed. Lenders deposit ℓ into a smart contract and receive a receipt in the form of a second token, labelled $c\ell$. Borrowers deposit collateral and withdraw token b. The ratio of their collateral to the borrowed amount is monitored automatically. These collateralized loans are designed so that the platform retains no credit risk,

[13] The next iteration of Uniswap, V3, shares similarities with limit order books in that liquidity can be posted in a price-contingent way.

[14] As tokens in the swap pool are deposited in equal value, the ratio of A to B is the b price of a.

and the lenders' claims are liquid or rather easy to withdraw.

These two goals are met by making the loans floating rate. (Borrowers and lenders receive different rates.) Rates are recalculated after each block is added to the chain and is increasing in the imbalance between the amount borrowed to the amount lent.[15] The overcollateralization and a floating rate mean that if demand to borrow a particular token is high, the rate on that token goes up. This does two things: first, it makes supplying the coin more attractive, and second, it reduces the overcollateralization of any borrowed positions.

Because the lenders' funds are pooled, individual lenders can withdraw their tokens at will. They do so by cashing in their $c\ell$ tokens, which grow in value according to the interest paid. Borrower positions are not pooled. Borrower default is mitigated by automated liquidations. Specifically, once collateral values fall relative to the amount borrowed, third-party liquidators are permitted to sell the collateral to repay the loan.

As of April 2023, the total value locked in Aave was USD 5.19 billion, and the protocol was operating on seven distinct blockchains. Compound was deployed on two chains and has USD 1.91 billion in total value locked. As these protocols lend cryptocurrencies against cryptocurrencies, they are more akin to repurchase markets (repo) than consumer lending.[16] Recall that in the repurchase market, loans of securities are also overcollateralized with other securities. Broadly, the market is designed to protect participants against counterparty risk. In the crypto lending market, credit risk cannot be directly assessed as participants' identities are not known. Thus, the system is also designed to protect lenders against counterparty risk.

Clearly, the design of both of the AMM and the lending protocol could be implemented without a blockchain. However, the design of both is such that they are easy to automate and therefore cheap and predictable. Of course, the price of the underlying tokens being traded and the rate at which they are lent can fluctuate, but the systems work as intended.

Making Payments

Limited on- and off-ramps from the traditional financial sector—and the fact that there is no natural numéraire in blockchain assets—led to the introduction of stablecoins, which serve as a means of payment and safe collateral in decentralized finance.[17] Figure 3 illustrates the five largest stablecoins.

The oldest and largest is Tether, which—together with USDC and BUSD—is a fiat-backed stablecoin. DAI is a crypto-collateralized stablecoin. DAI are generated as a series of collateral debt obligations by MakerDAO. To mint DAI, users deposit cryptocurrencies in a smart contract, which automatically issues debt in the form of DAI against the collateral. The protocol provides incentives to issue more or fewer DAI, which maintains the peg. Missing from the list are

[15] Blocks are added in Ethereum every seven seconds.

[16] Lehar and Parlour (2022) present evidence that these protocols are used for leveraged trading.

[17] A taxonomy of stablecoins appears in Klages-Mundt et al. (2020)

Stablecoin	Symbol	No Chains	Circulating Supply (bn USD)
Tether	USDT	63	81.5
USD Coin	USDC	61	30.7
Binance USD	BUSD	34	6.47
Dai	DAI	41	4.87
True USD	TUSD	10	2.13

Figure 3: The top five stablecoins by circulating volume. Data are current through April 2023. Source: DefiLlama

algorithmic stablecoins, which roughly operate as private central banks. Terra, the stablecoin (UST) and payments blockchain, which collapsed in May 2022, operated as an algorithmic stablecoin.[18]

Stablecoins are actively traded and used in decentralized finance. Curve, the automated market maker, is specially designed to allow trading between the largest stablecoins. Thus, prices of all stablecoins fluctuate around par value, subject to liquidity discounts or premia. Common to most means of payment, the facts that the large stablecoins are widely accepted and that the smaller stablecoins can be easily exchanged drive much of their value. However, fiat-backed stablecoins ultimately derive value from the fact that each token can be exchanged for fiat.

The mechanics of exchanging stablecoins for fiat differ across the various products. To redeem Tether for fiat, registered participants send the stablecoin to a specific smart contract (a wallet address), after which an equivalent value (minus a haircut) is wired to their bank account.[19] This process is akin to the creation/redemption observed in ETFs. By contrast, USDC can be exchanged for smaller bank balances at Coinbase or one of the other sponsors but at a small cost. Thus, both stablecoins do not actually provide payment against payment. But, insofar as both maintain their pegs, they are accepted as a means of payment.

Tether and Circle (the parent company of USDC) report that they hold high-quality, liquid reserves and are thus economically similar to narrow banks. Historically, the quality of reserves has been carefully examined. In February 2021, Tether and Bitfinex (an exchange) reached a settlement with the New York Attorney General.[20] Circle reserves were also under scrutiny with the collapse of Silicon Valley Bank. This is because 3.3 billion USD of its reserves were held at

[18] Uhlig (2022) describes the collapse.

[19] The minimum withdrawal is USD 100,000 at a cost of 10bps. The fee structure is outlined in https://tether.to/es/fees.

[20] Details of the settlement are available at https://ag.ny.gov/press-release/2021/attorney-general-james-ends-virtual-currency-trading-platform-bitfinexs-illegal. In addition, Griffin and Shams (2020) document various aspects of trading behavior.

the bank. After the FDIC receivership of Silicon Valley Bank, there was a brief depeg of USDC.

3 Web3 and Financial Infrastructure

Web3 can reduce costs both because, first, tokenized transactions on a blockchain effectively harmonize back-office operations and, second, delivery against payment allows more targeted use of collateral. If transactions occur on a blockchain, then there is no clearing or reconciliation step, thus reducing back-office costs as well as failures to deliver. Part of the efficiency gains stem from the fact that the parties transacting are effectively making entries in a common ledger, which streamlines the process.

The second benefit of tokenized transactions is that it permits delivery against payment. Currently, in most markets each transaction has two legs: one in which the price of exchange of various assets is agreed on, and one in which clearing and settlement occur and the trade is consummated. These legs occur asynchronously—there is typically a lag, necessitating a clearing mechanism that requires participating entities to post collateral and bear credit risk from other participants. [21]

Lags also exist in payments. Payments systems are both complex and country specific. However similar to asset markets, there is typically a separation between authorization and settlement. For example, messaging systems such as SWIFT verify instructions, but value is transferred through a different route. The sequence of nostro-vostro accounts that payments flow through all requires expensive pre-funding from the participating banks. In addition to regulatory compliance costs, collateral costs increase the costs of making payments.

Tokens themselves, once minted, can also be used in multiple ways. As a concrete example, consider someone who has deposited or supplied liquidity into an automated market maker. The receipt for doing this is a token, which is a claim to the deposited liquidity. This token can itself be used as collateral and pledged. This means that a liquidity provider who suffers a liquidity shock may leave their liquidity in the automated market maker and simply transfer the claim to someone else. By contrast, in traditional markets, a liquidity provider either has to borrow capital or withdraw their position. This novel feature potentially makes supplying liquid cheaper and markets more liquid.

Given the potential cost savings in automating clearing and settlement, various financial firms and services providers are experimenting with blockchains. The experiments are being run on both public and permissioned blockchains. Different firms are taking different approaches to this experiment. For example, Société Générale FORGE issues native digital assets on the public blockchain.[22] By contrast, Goldman Sachs has launched GS DAP, a private blockchain, while

[21] Acharya and Bisin (2014), Benos and Garratt (2017), Menkveld and Vuillemey (2021), Menkveld (2017), and Vuillemey (2020) present discussions on the complex design issues for the optimal clearing arrangement.

[22] See https://www.sgforge.com/

Oracle provides a suite of permissioned blockchain services.[23]

Currency Exchange

The forex market is the largest in the world, with a daily volume of USD 7.5 trillion, according to the Bank for International Settlement's (BIS) triennial survey. Continuous Linked Settlement facilitates payment versus payment during windows when the relevant country-specific wholesale payment systems are operational.

Through its innovation hubs, the BIS is investigating the use of automated markets for tokens. Project Mariana[24] uses a fork of the curve pool and is designed as a proof of concept. It is a joint project between the Banque de France, the Swiss National Bank, and the Monetary Authority of Singapore. In this project, financial institutions are both liquidity providers and traders. They swap tokenized central bank claims (wholesale CBDC) and are connected to their respective countries' wholesale payment systems. The benefit of such a system would be to integrate trade and settlement in one transaction. The proposed system is illustrated in figure 4 below.

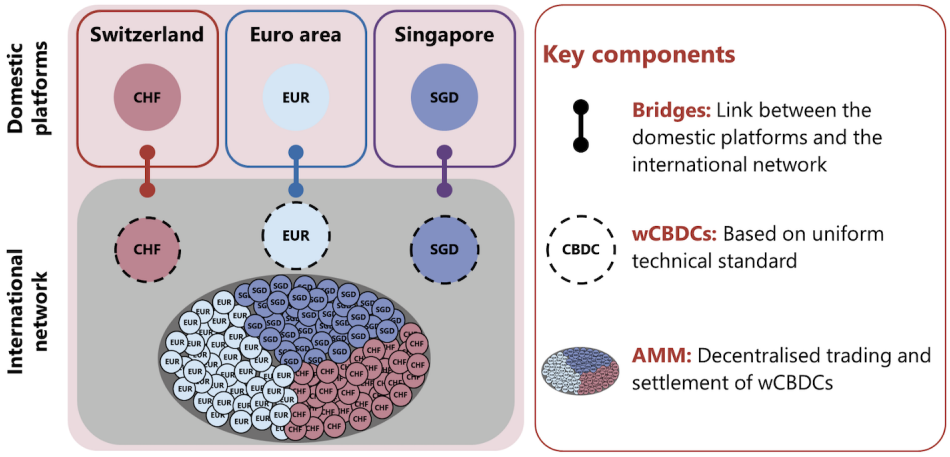

Figure 4: The Mariana Project for trade and settlement of wholesale CBDC.
Source: BIS

Ripple and Stellar are two blockchain-based companies that are trying to make value transfer cheaper. Ripple provides various services via the use of its native token, the XRP, which is roughly envisioned as an international payment medium or wholesale settlement coin. Fnality (formerly settlement coin) is also seeking regulatory approval to provide such services.

Trade Finance

One of the promises of smart contracts and decentralized systems is that it will dramatically reduce the costs of processes that involve checking conditions and then transferring value based

[23] See https://oracle.com/blockchain

[24] https://www.bis.org/about/bisih/topics/cbdc/mariana.htm

on the outcome of conditions. (Examples of such processes include bills of lading and purchase orders.) At each step of a complicated supply chain, goods have to be checked and documents are issued.[25]

Tradeshift provides a platform for purchase orders and invoices. The system experimented with smart contracts on the Ethereum blockchain to reduce costs for cross-border payments. It tokenizes invoices to produce "smart invoices," which has the usual elements (terms, underlying asset, etc.). When the invoice is "tokenized," whoever owns the invoice owns the underlying (real asset). After acceptance of the invoice, it executes following the contract terms and can be tied to money transfer. Specifically, the invoice tokens can be exchanged for payments.

Tradeshift Frontiers, in conjunction with Monerium (a fintech that is licensed to do money transfer and KYC/AML, etc.), tried to develop cross-border transactions involving euro-denominated e-money inside a smart contract. As a proof of concept, Tradeshift and Monerium settled invoices of €1024 (US$1,141.78), and then €512, at a fixed fee cost of 17 cents and 16 cents, respectively. In comparison, using ACH in the US typically costs somewhere between 20 cents and $1.50 in fixed fee, or 0.5 percent to 1.5 percent in variable fee.)

Monerium, under the EU e-money directive, is authorized to issue euros on chain. (These are not stablecoins, but rather euros that are issued as ERC-20 tokens.) The accepted smart contract issues a "FlowToken," which is ERC-20 compliant, and a payment commitment with a due date. When the contract terms of the smart contract are verified, these tokens are automatically sent to a firm's public key via a swap with the Monerium on-chain €.

Though this system is still proof of concept, it has obvious financial uses. Besides reducing costs and human error, a tokenized smart invoice is easy to use for financial applications such as trade credit and factoring.

Remittances

The World Bank estimated remittance flows of $629 billion in 2022. Sending this money was also expensive: the World Bank's Remittance Prices Worldwide Database reports the cost of sending $200 to be 6%.[26] There are various reasons for the cost. First, competition is difficult in payment systems.[27] Second, the correspondent banking system (based on nostro vostro accounts) adds both time and expense to moving value and settling international transactions. Also, concern has been growing that the number of correspondent banks, especially in smaller corridors, is falling.[28] All of this adds to the cost of transferring value.

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[25] Inthanon-Lionrock (2018) reports on an experiment in automating cross-border trade to reduce costs.

[26] Knomad (2022)

[27] Payment systems are multi-sided markets with network effects. In such markets, cheaper payment rails cannot necessarily undercut incumbents enjoying large network externalities.

[28] This is documented in BIS (2016)

Recently, Adams et al. (2023) present evidence from a Uniswap pool in which traders exchange euro stablecoins versus US stablecoins both issued by Circle (EUROC and USDC). In a six-month sample, they document that there is consistent liquidity and that prices are within a few basis points of larger forex markets. As retail investors and small and medium enterprises have access to Uniswap pools, their further finding is that these decentralized payment-against-payment solutions could lead to substantial cost reductions: up to 80 percent. Figure 5 shows how value could be transferred. Of course, such a system would not work for recipients who do not have access to suitable on- or off-ramps—that is, those who are unbanked or only use cash.

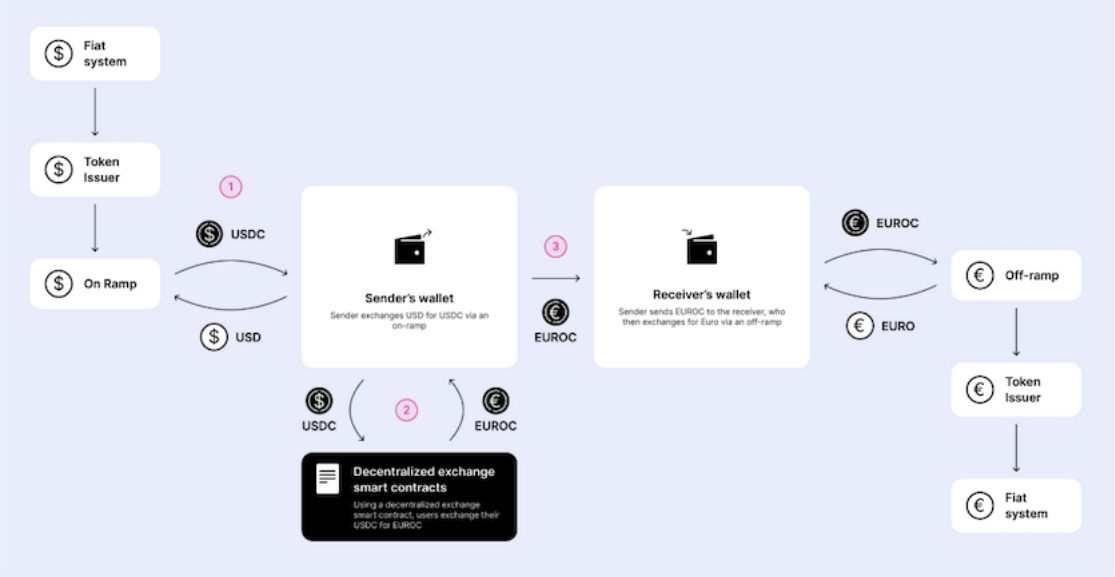

Figure 5: Schematic of a potential retail decentralized exchange rate mechanism. Source: Adams et al. (2023)

Making Assets More Liquid

Assets differ in the degree to which they can be traded, and illiquidity typically depresses the price of the asset. Some of the reasons why assets are illiquid cannot be solved by technology (such as dubious quality or other forms of uncertainty). However, some assets are illiquid because they are large (infrastructure loans), because of legal frictions in buying and selling (real estate), and because counterparties are difficult to find. Technology can mitigate these concerns.

Tokeny, a Luxembourg company, offers a white-label token solution. Specifically, it provides a regulatory-compliant way to tokenize assets, which can then be held, sold, and transferred more easily. Similarly, the Provenance blockchain—a private blockchain focused on financial applications—provides a suite of services including custody and management of fixed-income assets. As payments, cash flows, etc., are predictable for these assets, they are amenable to automation. Further, nonfungible tokens can identify specific items. Concretely, a deed of trust and mortgage note can be carefully separated, which may make securitization more efficient and transparent and the claims more liquid.

Automated margin enforcement is one of the possibilities in decentralized finance.

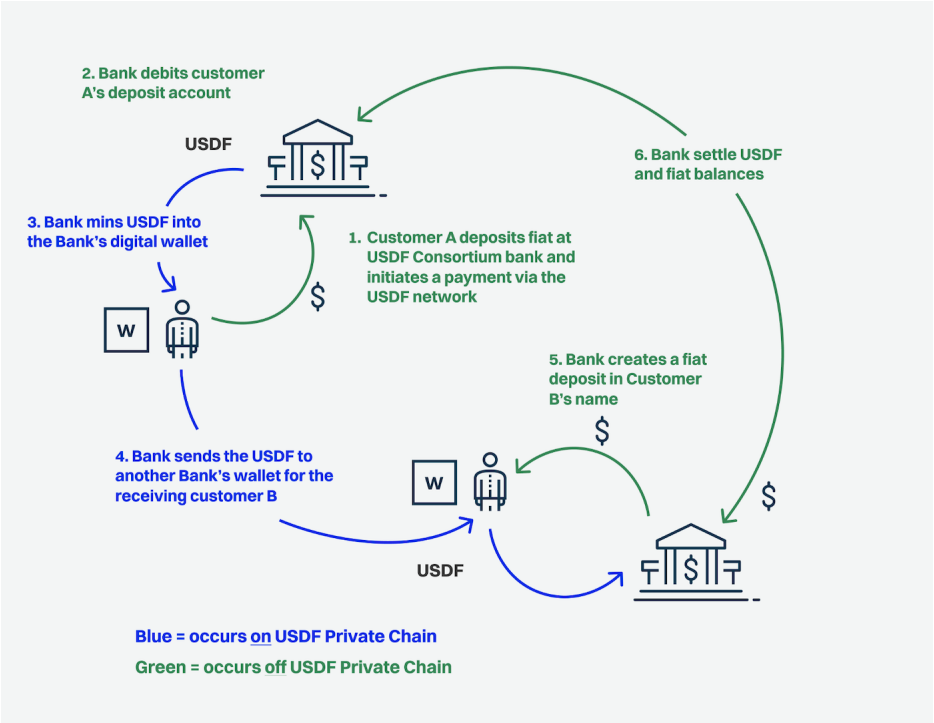

Figure 6: Use of the USDF digitized deposit
Source: USDForward consortium

Currently, in traditional finance, margin requirements are enforced in vertically integrated silos with trading. Specifically, brokers or intermediaries who want to encourage trades are also responsible for tracking margins. These dual roles have occasionally led to financial catastrophes.[29] Automated margins reduce credit risk (at the expense of discretion) but may increase asset price volatility.

Making Domestic Payments More Efficient

Interim between completely private stablecoins and a central bank digital currency are digital deposits. This type of deposit is already operating in the United States. USD Forward is a consortium of banks that are using some of these techniques to tokenize customer deposits. Although they still settle through the Federal Reserve, customer deposits are digitized and swapped on a permissioned blockchain – the Provenance blockchain. This model of digitized deposits allows banks to provide regulated stablecoins and gives then the flexibility to issue inside money.

Through these tokenized deposits, customers have real-time, programmable payments. Figure 6 illustrates how a customer interacts with the Provenance blockchain through their bank. The bank mints deposits for the customer, who can then use them with other customers participating in the consortium.

[29] Margin calls in 2022 in nickel contracts on the London Metal Exchange threatened the financial stability of various brokers.

Other jurisdictions have indicated an interest in digitized deposits. The Swiss banker's association has proposed a deposit token for the Swiss franc.[30]

4 Regulatory Challenges and Future Outlook

Regulations, insofar as they rely partly on history, are backward looking. For example, liquidity coverage ratios are determined by historical withdrawals. However, with technology adoption, behavior will change. A recent report from the Federal Reserve on the collapse of Silicon Valley Bank noted the speed with which deposits at scale were withdrawn.[31] This event reflects the speed with which information was shared and the ease of moving digital money.

It is also worth noting that our understanding of asset markets and how they react to shocks is based on the current organization of the financial system. Specifically, moving from a system in which various functions such as margins, collateral management, etc., are integrated to one in which they are performed in a different way by different parties may change the way in which asset prices behave and how the overall system reacts to shocks. For example, when hit by a shock, people rebalance their portfolios and change the liquidity or change the risk. As regulations and market structures change, so will the most liquid assets, and the safest asset. For example, after the run on Silicon Valley Bank and the temporary depegging of USDC, approximately 2 billion of new DAI were minted. Usually, we do not associate a flight to quality towards crypto-collateralized stablecoins.

Further, shocks may propagate though Web3 markets in unanticipated ways. As noted above, AMM's liquidity provision is tokenized. (Other aspects of other dapps can also be tokenized.) As various tokens hold value, they are frequently accepted as collateral in other applications. The darker side of using tokens as collateral is that it generates interconnectedness among various protocols, which makes estimating or understanding systemic risk more challenging for regulators.

Overall, the technological and economic innovations developed in Web3 provide the tools to automate many types of financial transactions. This is important because automation can reduce the cost of financial intermediation and make processes more predictable. Despite growing in absolute size, and as a percentage of GDP, the finance industry has not become more efficient.[32] The finance sector underpins our modern economy, and all benefit from reducing transaction costs and streamlining processes.

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[30] Available at https://www.swissbanking.ch/_Resources/Persistent/9/4/1/1/941178de59b98030206fc15ac8c99012f65df30b/SBA_The_Deposit_Token_EN_2023.pdf

[31] https://www.federalreserve.gov/publications/files/svb-review-20230428.pdf

[32] Philippon (2015) considers changes in the cost of financial intermediation over the last century and reports constant returns to scale of 1.5 percent to 2 percent of intermediated assets in the finance industry.

References

Acharya, Viral, and Alberto Bisin. 2014. "Counterparty risk Externality: Centralized versus over-the-counter markets." *Journal of Economic Theory*, 149: 153–182.

Adams, Austin, Mary-Catherine Lader, Gordon Liao, David Puth, and Xin Wan. 2023. "On-Chain Foreign Exchange and Cross-Border Payments." *Available at SSRN*.

Benos, Evangelos, and Rod Garratt. 2017. "The economics of distributed ledger technology for securities settlement." *manuscript*.

BIS. 2016. "Correspondent Banking." *Committee on Payments and Market Infrastructure*.

Cong, Lin William, Ye Li, and Neng Wang. 2021. "Tokenomics: Dynamic Adoption and Valuation." *The Review of Financial Studies*, 34: 1105–1155.

Cong, Lin William, Ye Li, and Neng Wang. 2022. "Token-based Platform Finance." *Journal of Financial Economics*, 144: 972–991.

Griffin, John, and Amin Shams. 2020. "Is Bitcoin really untethered?" *The Journal of Finance*, 75: 1913–1964.

Inthanon-Lionrock, Project. 2018. *Bank of Thailand, and Monetary Authority of Hong Kong*.

Klages-Mundt, Ariah, Dominik Harz, Lewis Gudgeon, Jun-You Liu, and Andreea Minca. 2020. "Stablecoins 2.0: Economic foundations and risk-based models." 59–79.

Knomad, World Bank Group. 2022. "Remittance Brave Global Headwinds." *Migration and Development Brief*, 37.

Lehar, Alfred, and Christine Parlour. 2021. "Decentralized Exchanges." *available at SSRN*.

Lehar, Alfred, and Christine Parlour. 2022. "Systemic Fragility in Decentralized Markets." *available at SSRN*.

Menkveld, Albert J. 2017. "Crowded positions: An overlooked systemic risk for central clearing parties." *The Review of Asset Pricing Studies*, 7(2): 209–242.

Menkveld, Albert J, and Guillaume Vuillemey. 2021. "The economics of central clearing." *Annual Review of Financial Economics*, 13: 153–178.

Philippon, Thomas. 2015. "Has the US finance industry become less efficient? On the theory and measurement of financial intermediation." *American Economic Review*, 105(4): 1408–1438.

Uhlig, Harald. 2022. "A luna-tic Stablecoin Crash." *Becker Friedman Institute for Economics Working Paper*, 2022-95.

Vuillemey, Guillaume. 2020. "The value of central clearing." *The Journal of Finance*, 75: 2021–2053.